

PCM Passive Cooling System Containing Active Subsystems

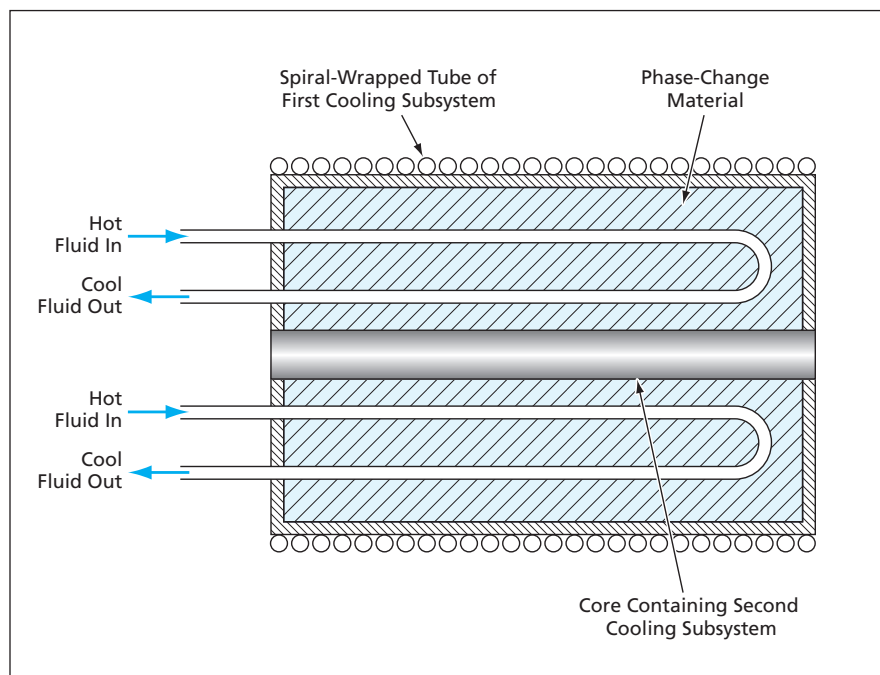
A PCM would absorb intense heat bursts and would be regenerated between them.

Lyndon B. Johnson Space Center, Houston, Texas

A multistage system has been proposed for cooling a circulating fluid that is subject to intermittent intense heating. The system would be both flexible and redundant in that it could operate in a basic passive mode, either sequentially or simultaneously with operation of a first, active cooling subsystem, and either sequentially or simultaneously with a second cooling subsystem that could be active, passive, or a combination of both. This flexibility and redundancy, in combination with the passive nature of at least one of the modes of operation, would make the system more reliable, relative to a conventional cooling system.

The system would include a tube-in-shell heat exchanger, within which the space between the tubes would be filled with a phase-change material (PCM). The circulating hot fluid would flow along the tubes in the heat exchanger. In the basic passive mode of operation, heat would be conducted from the hot fluid into the PCM, wherein the heat would be stored temporarily by virtue of the phase change.

Of course, it would become necessary to remove heat from the PCM to maintain or restore its heat-absorption capacity. This would be accomplished by means of the first, active cooling subsystem, which would circulate a cooling fluid through one or more tube(s) in thermal contact with the PCM. For example, such a cooling tube could be wrapped in a spiral around the heat-exchanger shell as shown in the figure.



This Cross Section Is Greatly Simplified to show only selected major features of a heat exchanger according to the proposal.

The heat exchanger would include an inner core that would accommodate the second cooling subsystem. As mentioned above, the second cooling subsystem could be active, passive, or both. This subsystem would remove heat from the core by means of heat pipes, a water membrane evaporator, and/or one or more active refrigeration devices. In the case of a water membrane evaporator,

heat would be dissipated in the environment by releasing the steam generated at the membrane.

This work was done by David E. Blanding and David I. Bass of the Boeing Co. for Johnson Space Center. For further information, contact the Johnson Innovative Partnerships Office at (281) 483-3809. MSC-23652

Automated Electrostatics Environmental Chamber

Atmospheric temperature and pressure can be varied between the extremes of Mars and Earth.

John F. Kennedy Space Center, Florida

The Mars Electrostatics Chamber (MEC) is an environmental chamber designed primarily to create atmospheric conditions like those at the surface of Mars to support experiments on electrostatic effects in the Martian environment. The chamber is equipped with a vacuum system, a cryogenic cooling system, an atmospheric-gas replenishing and analysis system, and a computerized control system that can be programmed by the user and that provides both au-

tomation and options for manual control. The control system can be set to maintain steady Mars-like conditions or to impose temperature and pressure variations of a Mars diurnal cycle at any given season and latitude. In addition, the MEC can be used in other areas of research because it can create steady or varying atmospheric conditions anywhere within the wide temperature, pressure, and composition ranges between the extremes of Mars-like and

Earth-like conditions.

The MEC (see figure) includes access ports for installation and removal of experimental devices, and vacuum-feed-through ports for connecting to the devices from the outside. Also included are feed-through ports for pressure sensors, thermocouples, and gas-supply tubes that are permanent parts of the apparatus. There also are access ports for visual monitoring of experimental devices.

The temperature in the chamber can



The **Mars Electrostatics Chamber** has an external length of 2 m, external diameter of 1.3 m, and interior volume of 1.5 m³. The chamber houses an experiment deck measuring 1.43 by 0.80 m. This apparatus is versatile enough to be useful for general research in addition to research on electrostatics in the Martian environment.

range from a minimum of 150 K to a maximum of 473 K. The temperature at 48 different locations within the chamber is monitored by use of thermocouples. Temperature is controlled mainly by balancing (1) the inward leakage of heat from ambient temperature against (2) the removal of heat by circulation of a mixture of warm gaseous nitrogen and cold vaporized liquid nitrogen through a cooling shroud inside the chamber. The rates of flow of the warm and cold nitrogen are monitored by flowmeters and regulated by controllable valves. Additional heating is provided by tape heaters outside the

chamber and additional cooling by a liquid-nitrogen cold plate.

Following initial evacuation, the chamber is backfilled with an atmospheric gas mixture (e.g., CO₂ with small amounts of N₂, Ar, O₂, and H₂O to simulate the Martian atmosphere) at low pressure [typically between 6 and 9 millibars (between 600 and 900 Pa) for the Martian atmosphere]. Thereafter, pressure is brought to and maintained at the required value by use of a feedback control system that balances the rate of flow of atmospheric gas into the system against the rates of leakage and of vac-

uum pumping. The feedback control system includes a pressure sensor and a gas-feed throttle valve.

The composition of the gas is monitored by use of a separately operated residual-gas analyzer, the output of which is sent to the computerized control system. A mass flow controller maintains the desired relative concentrations of the gases in the atmospheric gas mixture.

A programmable logic controller (PLC) is the heart of the computerized control system. The PLC accepts inputs from a manual control panel, capacitance manometers, flowmeters, pressure controllers, and thermocouples. The PLC provides outputs to indicators on the manual control panel, and to the vacuum, heating, cooling, pressure, and gas-composition systems described above. Numerous outputs are sent to a graphical user interface (GUI) that features "soft" controls and indicators that emulate those of the manual control panel with the addition of elaborate graphical management capabilities. The GUI notifies the PLC when it is ready to accept or provide information relative to the control process. Optionally, the operation of the MEC can be controlled by use of the manual control panel alone, or partly by use of the manual control panel and partly by use of the GUI. This option affords flexibility for manually performing tests while maintaining safe operation by use of automatic control.

*This work was done by Carlos Calle and Dean C. Lewis of **Kennedy Space Center**, and Randy K. Buchanan and Aubri Buchanan of VirCon Engineering. For further information, access <http://technology.ksc.nasa.gov/WWWaccess/techreports/2001report/200/207.html>. KSC-12590*

Automated Electrostatics Environmental Chamber

Lyndon B. Johnson Space Center, Houston, Texas

A solid-phase extraction (SPE) process has been developed for removing alcohols, carboxylic acids, aldehydes, ketones, amines, and other polar organic compounds from water. This process can be either a subprocess of a water-reclamation process or a means of extracting organic compounds from water samples for gas-chromatographic analysis. This SPE process is an attractive alternative to an Environmental Protection Administration liquid-liquid extraction process that generates some pollution and does not

work in a microgravitational environment. In this SPE process, one forces a water sample through a resin bed by use of positive pressure on the upstream side and/or suction on the downstream side, thereby causing organic compounds from the water to be adsorbed onto the resin. If gas-chromatographic analysis is to be done, the resin is dried by use of a suitable gas, then the adsorbed compounds are extracted from the resin by use of a solvent. Unlike the liquid-liquid process, the SPE process works in both

microgravity and Earth gravity. In comparison with the liquid-liquid process, the SPE process is more efficient, extracts a wider range of organic compounds, generates less pollution, and costs less.

*This work was done by Richard Sauer of **Johnson Space Center**, Jeffrey Rutz of Krug Life Sciences, and John Schultz of Wyle Laboratories.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22899.